

## ACCOMPLISHMENT REPORT

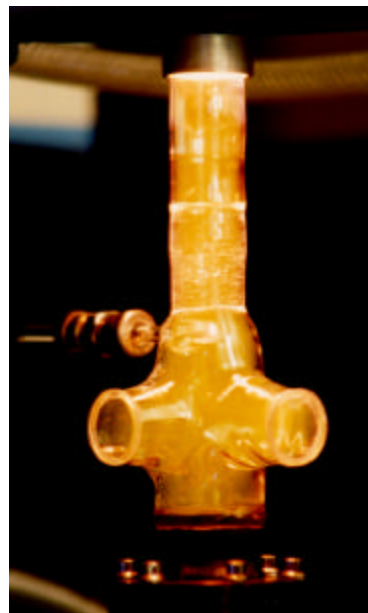
### PROPULSION DIRECTORATE

July 1999

MORRIS AND BUCHHALTER WIN YATES AWARD: Messrs. Robert W. Morris Jr. and George Buchhalter Sr. of the Fuels Branch (AFRL/PRSF) were recently awarded the 1998 General Ronald W. Yates Award for Excellence in Technology Transfer. Morris and Buchhalter were honored for their work on the demonstration of the +100 fuel additive in the helicopters of two Florida law-enforcement agencies. Through the use of the +100 additive, these law-enforcement units experienced a significant reduction in maintenance costs while increasing safety of flight. These results vividly demonstrated the benefits of the +100 additive and highlight its potential for use outside of the military. The Yates Award honors Gen Yates' numerous and lasting contributions to the Air Force Science and Technology Program. This award was established upon Gen Yates' departure from active duty as the first Commander of Air Force Materiel Command (AFMC) as a tribute to his achievements and support of technology transfer. (W. Harrison, AFRL/PRSF, (937) 255-6601)

### DISSERTATION SUPPORTS PLASMA PROCESSING

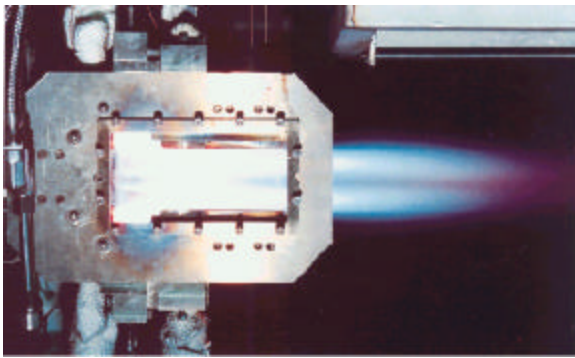
RESEARCH: Steve Adams (AFRL/PRPS) recently received a Ph.D. in Chemical Physics from The Ohio State University for his dissertation entitled "Studies of Atomic Nitrogen in Low Pressure Discharges by Two-Photon Laser Induced Fluorescence." This work is relevant to Power Division (AFRL/PRP) research since the physical and chemical information gathered can be used to optimize plasma processing techniques for electronic materials. Nitrogen discharges are of considerable interest as the atomic nitrogen produced in these discharges is an essential ingredient in plasma processing recipes, such as deposition of nitride materials for use as dielectric or semiconducting layers, nitrogen doping of various semiconductors, and nitride hardening of steel surfaces. The dissertation research was primarily experimental and concentrated on the development, characterization, and application of an advanced laser diagnostic technique for remote measurement of the absolute atomic nitrogen density within the discharge cell. This detection scheme was shown to be superior in many respects to the standard atomic nitrogen detection scheme in use over past decades. A numerical modeling effort also accompanied the experimental work. Based on this work, Dr. Adams published an article in *Chemical Physics Letters* in October 1998, presented papers at the 1997 and 1998 Gaseous Electronics Conferences, and is preparing two more refereed journal articles. (S. Adams, AFRL/PRPS, (937) 255-5179)



The amber colored afterglow downstream of a microwave discharge indicates the strong presence of atomic nitrogen

ROCKET PREBURNER SUCCESSFULLY TESTED: A new generation of rocket preburner technologies recently took another step closer to fielding with the successful completion of ignition tests under the Integrated Powerhead Demonstration (IPD) project. In previous testing under contract to the Rocket Propulsion Division (AFRL/PRR), Aerojet had successfully tested a hydrogen fueled preburner. In the most recent tests under the same contract, Aerojet has tested their new oxygen preburner. In the oxygen preburner, hydrogen and oxygen are burned to provide hot oxygen-rich gases necessary to drive the oxygen turbine in a high performance rocket engine. These successful ignition tests provide verification of the preburner design and generate performance data needed to complete the engine start sequence design. Additionally, the new preburner technologies employed significantly reduce fabrication costs and improve temperature uniformity resulting in longer turbine life. The oxygen preburner is the second hardware item from the IPD project to be ready for full power integrated tests. The IPD project offers significant reduction in life cycle costs and increased performance for highly reusable rocket engines in future force application systems. (L. Quinn, AFRL/PRR, (661) 275-5630)

INNOVATIVE COMBUSTOR TESTING CONTINUES: Personnel from the Combustion Branch (AFRL/PRSC) and General Electric Aircraft Engines (GEAE) recently completed the first three of four phases of single cavity Trapped Vortex Combustor (TVC) tests. The TVC is a unique turbine engine combustor concept that offers reduced emissions and improved performance in a small, simple, low cost package. Benefits from the TVC concept can be realized for aircraft propulsion as well as marine, industrial, and electrical power generation applications. In recent testing, the overall fuel-to-air ratio, combustor flow loading, cavity-main air split, and main combustor were investigated using emissions sampling, temperature profiling, and lean blow-out tests. Measured combustion efficiencies ranged from



Trapped Vortex Combustor

88% to more than 99% depending on the flow conditions. These tests provided a great deal of insight into the fluid dynamics occurring in the combustor with respect to the structure and stability of vortices and their dependence on flow parameters. The single cavity TVC looks very promising and could provide significant thrust-to-weight ratio advantages. Furthermore, the simplicity of the TVC design offers the potential for significant reductions in manufacturing costs. (1Lt I. Vihinen, AFRL/PRSC, (937) 255-8623)

HAWKINS NAMED SCIENTIST OF THE YEAR: Dr. Tom Hawkins of the Propellants Branch (AFRL/PRSP) at Edwards Air Force Base was recently honored for his efforts. On 23 June 1999, Dr. Hawkins received the Edwards AFB Civilian Scientist/Engineer of the Year award from the Air Force Flight Test Center (AFFTC). Dr. Hawkins received his award from Maj Gen Richard V. Reynolds, Commander of AFFTC, for his groundbreaking work on the AFRL Advanced Monopropellant Research and Development Program. Monopropellants combine the properties of fuel and oxidizer in one chemical and are typically used in adjusting or vernier rockets to provide thrust for making changes to orbits. The achievements of Dr. Hawkins in pursuit of improved monopropellants make him a worthy recipient of this prestigious award. (T. Hawkins, AFRL/PRSP, (661) 275-5449)



Dr. Tom Hawkins

NEW FUEL PUMP FOR THE KC-135: The Power Division (AFRL/PRP) recently embarked on a research program with Chandler Evans Control Division (CECO) of Coltec Industries to fully design and develop a Variable Displacement Vane Pump (VDVP) for the KC-135. The VDVP is intended as a replacement for the engine fuel pump on the KC-135's GE F108 engines. The F108 engines currently use a traditional gear-type fuel pump that delivers a fixed displacement of fuel at all operating conditions. The pump is sized for peak fuel flow conditions such as takeoff; therefore, at other flight conditions, such as cruise, excess fuel is recycled back through the pump inlet or through the fuel tanks for cooling purposes. This recycling process puts considerable stress on the fuel as the fuel is heated and degraded when pumped. The VDVP is designed to minimize fuel recycling thereby reducing the fuel temperature rise and the associated degradation of the fuel. Additionally, gear pumps must be overhauled every 5,000-10,000 hours and eventually replaced as performance degrades. The maintenance cost associated with pump overhaul and replacement can amount to several million dollars per year. Due to its design and the use of advanced materials, the VDVP is expected to last at least twice as long as the current gear pump before needing overhaul and/or replacement. This represents a tremendous potential cost savings. The VDVP will be built and installed on an engine for ground testing, and flight testing and full qualification will follow if funds become available. This program has benefits to a More Electric Aircraft (MEA) as the VDVP is an ideal pump to be rotated by a simple induction motor, either at a constant speed or at a speed proportional to engine speed. (J. Tschantz, AFRL/PRPG, (937) 255-6241)



KC-135 Stratotanker

MAURICE WINS AIAA CHAIRMAN'S AWARD: Dr. Lourdes Maurice of the Fuels Branch (AFRL/PRSF) recently received the Chairman's Award from the Dayton-Cincinnati Section of the American Institute of Aeronautics & Astronautics (AIAA). Richard E. Quigley Jr., AIAA Dayton-Cincinnati Section Chairman and Acting Director of the AFRL's Propulsion Directorate, presented this award to Dr. Maurice at the section's awards banquet on 26 May 99. Dr. Maurice received this award for her outstanding service as the section Vice-Chairperson. She was also recognized for her tremendous efforts to organize the highly successful 24<sup>th</sup> Annual Dayton-Cincinnati Aerospace Sciences Symposium. This annual event brings together the finest aerospace researchers in the local area to exchange information and ideas. This year's event set new records with more than 190 papers presented and over 300 participants. (J. Pearce, AFRL/PRO, (937) 255-5451)



Dr. Lourdes Maurice

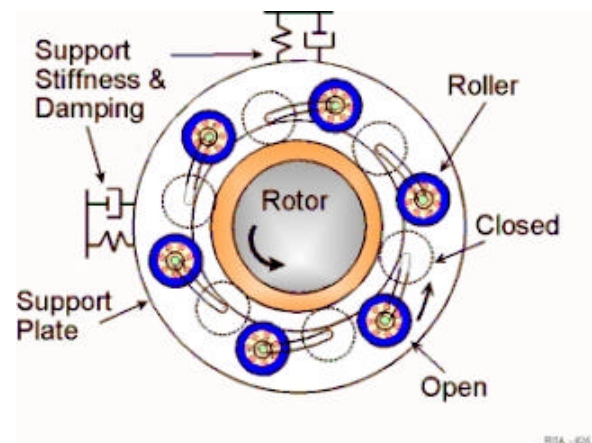
SiC BENEFIT STUDY INITIATED: The Power Generation & Thermal Management Branch (AFRL/PRPG) initiated a contract with Northrop in 1993 to study the thermal management challenges for a More Electric Aircraft (MEA). The F/A-18E was used as a baseline to compare secondary power system and flight controls to those for a more-electric version. In 1998, this contract was modified to include an assessment of the potential benefits of using SiC-based power electronic components in an MEA aircraft power system, and this task has just gotten under way. SiC components allow for much higher operating temperatures (e.g., upwards of 300°C) and power densities than conventional electronic components. Higher operating temperatures may be used to relax some of the thermal constraints by allowing higher temperature peak excursions. On the other hand, the

higher power density and waste heat flux at elevated temperatures present significant new heat acquisition challenges. These tradeoffs will be assessed at the power subsystem level in this effort. This study is particularly relevant to the high power directed energy missions envisioned for the near future. Northrop is working with Science Applications International Corporation (SAIC) on the Combat Hybrid Power System (CHPS) Program studying directed-energy applications for tanks. The Power Division (AFRL/PRP) is in an outstanding position to leverage this multimillion-dollar DARPA-funded power project. (B. Donovan, AFRL/PRPG, (937) 255-6241)

AUXILIARY BEARINGS FOR ADVANCED ENGINES: Mohawk Innovative Technology, Inc was recently awarded a Phase II SBIR for the development of a high temperature zero clearance auxiliary bearing (ZCAB). In this Lubrication Branch (AFRL/PRSL) managed program, Mohawk will continue the development of the ZCAB, which is a device intended to provide a low maintenance back-up bearing for turbomachinery supported by magnetic bearings. The target application for this bearing technology is the hot section in the second build of the Integrated High Performance Turbine Engine Technology (IHPTET) Phase III Advanced Turbine Engine Gas Generator (ATEGG) demonstrator. Since both General Electric and Allison Advanced Development Company have a vested interest in the ATEGG Phase III demonstrator, they will participate in the ZCAB development. Having all of the concerned parties involved in the ZCAB development and design will enhance the probability of a successful program. The program kickoff meeting was held at Mohawk's facilities in Albany NY on 13-14 July 1999. (R. Wright, AFRL/PRSL, (937) 255-5568)



Zero Clearance Auxiliary Bearing



Schematic of ZCAB operation

COLD FUEL ADDITIVE WORK GAINS SUPPORT: Following the Annual Program Review for the U-2 reconnaissance aircraft, the Mission Area Directorate for Information Dominance (SAF/AQI) has agreed to fund development of a low temperature fuel additive for JP-8. Motivation for this effort stems primarily from a desire to replace JPTS (TS for *thermally stable*), the fuel used for the U-2, with the more economical JP-8 as the cost of JP-8 is approximately one-third the cost of JPTS (\$0.80/gallon vs \$2.50/gallon). However, the U-2 requires a fuel with a freezing point below that of standard JP-8, thus it is necessary to develop a low-cost fuel additive for JP-8 that will extend its low temperature operating capability. A feasibility/risk reduction study on the additive development was recently completed resulting in a reduction of the program risk from “very high” to “moderate to low.” Research to develop the additive will be a joint program between the Fuels Branch (AFRL/PRSF), the University of Dayton Research Institute (UDRI), General Electric, and Boeing. In addition, the Materials & Manufacturing Directorate (AFRL/ML) will be participating in material compatibility tests for candidate fuel additives and the Human Effectiveness Directorate (AFRL/HE) will be involved in an assessment of additive toxicity. The additive development program is projected to be a five-year program, and funding is currently in place to carry the program to the end of FY00. (C. Obringer, AFRL/PRSF, (937) 255-6390)



U-2 Dragon Lady

POWER DIVISION SUPPORTS SPACE BASED LASER FLIGHT EXPERIMENT: The Space Based Laser Integrated Flight Experiment (SBL/IFX) Program kicked-off during the week of 7 June 1999, and the Power Division (AFRL/PRP) is lending their support to the effort. The SBL/IFX Program is a major step toward achieving the Air Force’s vision of migrating to the Space & Air Force. Three prime contractors, Boeing, TRW, and Lockheed-Martin (LM), are non-competitively teamed and are working toward an IFX flight date of 2012. The present baseline laser for the IFX is a chemical hydrogen-fluorine (HF) system. The electrical power requirements for this system are at the limit of what is commercially available, and these requirements will undoubtedly grow. Therefore, the program is highly reliant on advanced electrical power system technologies to keep the system mass within launch vehicle capacity, and PRP will lend its expertise in this area. PRP is also supporting the contractors on an Affordability and Architecture Study (AAS) Program that is designed to provide competitive bids for the operational system once the non-competitive IFX Program is completed. The AAS will periodically assess the state of the art and future potential of competitive SBL technologies and weigh them against the baseline chemical HF system. PRP has provided information to the LM/TRW team for an electrical laser power system and is in the process of doing the same for Boeing. The contractors have only recently learned of the advancements made in battery, power conditioning, and thermal control technologies developed by PRP. These recent studies have shown that solar-battery electrical alternatives are mass-competitive with the baseline chemical system, and have the added benefit of

eliminating the need for refueling. A solar-battery electrical laser would also add tremendous mission capability. Ancillary missions such as LIDAR imaging, battlefield illumination, and non-BMD/TMD target kill make this alternative extremely attractive once feasibility is determined. (J. Leland, AFRL/PRPG, (937) 255-6241)

INJECTABLE SOLUTION SOLID PROPELLANT DEVELOPMENT: Ecotech was recently awarded a Phase I SBIR contract to develop an injectable solution solid propellant. This Rocket Propulsion Division (AFRL/PRR) managed program will develop technology that will make the design of low-cost, high performance rocket motors possible. These motors will be used for boosting military and commercial payloads into earth orbit. Additionally, the technology being developed under this program has applications beyond rocket motors. Applications such as gas generators, automotive airbags, and other devices that need to deploy gases quickly, efficiently, and safely could greatly benefit from this type of system. (L. Quinn, AFRL/PRR, (661) 275-5630)

SERDP ENDORSES ENVIRONMENTALLY FRIENDLY COMBUSTOR DESIGN: The Combustion Branch (AFRL/PRSC) recently received \$350,000 of fallout funds from the Strategic Environmental Research and Development Program (SERDP). These monies are tagged for continued research and development of the Trapped Vortex Combustor (TVC), a turbine engine combustor that offers low emissions and excellent performance in a low cost package. SERDP provided these funds as a result of their enthusiastic approval of a report commissioned by the American Academy of Environmental Engineers (AAEE). AAEE commissioned Dr. W. Melvyn Roquemore of PRSC to prepare a report for SERDP on emissions from DoD vehicles with gas turbine powerplants. In June, Dr. Roquemore presented an overview of this report to the AAEE in Baltimore MD. Later this year, the report will be published along with reports on ordnance and diesel emissions. The book will also contain the results of the AAEE workshops on emissions formation processes, the control of emissions, instrumentation, and the establishment of an emissions database. The report on emissions from DoD vehicles was a collaborative effort between PRSC, the Fuels Branch (AFRL/PRSF), and on-site contractor Innovative Scientific Solutions, Inc (ISSI). (1Lt I. Vihinen, AFRL/PRSC, (937) 255-8623)

INVESTIGATING ADVANCED ENGINE CONCEPTS: HyPerComp, Inc was recently awarded a Phase I SBIR titled, "Multi-Mode Propulsion Technology for High Performance Applications." A kickoff meeting was held on 16 June 1999 attended by representatives of PR-East, PR-West, and the Office of Naval Research's (ONR) pulse detonation engine technology manager, Dr. Gabriel Roy. HyPerComp's Phase I team includes Lockheed-Martin Tactical Aircraft Systems (LMTAS) and the University of Texas at Arlington. The proposed Phase I effort is primarily conceptual and numerical in scope. In the conceptual portion of the work, mission specifications will be established. Thrust, specific impulse, fuel mass fraction, and other performance goals will be determined by a study of matching designs from recent literature and studies conducted at LMTAS. Numerical studies will then be used to refine and develop confidence in the proposed designs. HyPerComp's engine concept is a rocket based combined cycle (RBCC) engine concept that incorporates a pulse-detonation rocket acting as an ejector, a pulsed normal detonation wave, and a steady oblique detonation wave. The propulsion system is intended for single stage to orbit (SSTO) as well as atmospheric cruise applications. Experimental work is planned for Phase-II of the program. (S. Mozes, AFRL/PRST, (937) 255-9991)

IMPROVING SERVICE LIFE PREDICTIONS FOR ROCKET MOTORS: On 28 May 1999, the Rocket Propulsion Division (AFRL/PRR) established the Critical Defect Assessment (CDA) Program with Thiokol Corporation. Under this contract Thiokol will perform propellant sample testing and produce software to enhance the capabilities of existing service life prediction methods. These service life prediction methods are part of the Structural Ballistic Assessment System (SBAS). This is a critical issue as aging of the propellant may affect reliability, performance, and safety of the rocket motor. These aging processes are strongly dependent on the conditions to which the motor has been exposed such as temperature and humidity. Integrated High Payoff Rocket Propulsion Technology (IHDRPT) goals are to have a 10-year predictive capability on the useful life of propellants, to reduce analysis method uncertainties by 9 percent, and to reduce characterization uncertainties by 7 percent. The CDA is part of the Technology for the Sustainment of Strategic Systems (TSSS), which is a program designed to sustain the ability of industry to design future ballistic missiles. This contract is valued at more than \$5 million and runs through FY 2003. (L. Quinn, AFRL/PRR, (661) 275-5630)